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IMPROVEMENT IN THE NUTRITIVE VALUE OF WHEAT STRAW BY BIOLOGICAL TREATMENT*

F.H. Shah, Zia-ur-Rehman, A. Majid, T. Firdous and A.D. Khan

PCSIR Laboratories, Lahore. Pakistan

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In vivo digestibility of straw hydrolysed by cellulolytic microorganism showed an increase from 42.27 to 50.03 %. Maximum dry matter digestibility was 68.83 % when a combination of *Chaetomium globosum* and *Bacillus polymyxa* was propagated on alkali treated straw. An improvement in the digestibility of nitrogen, cellulose, minerals and fibre contents was also observed.

INTRODUCTION

Vast quantities of agricultural and forest by-products accumulate each year, resulting in deterioration of the environment and a loss of potentially valuable resources. These by-products contain cellulose and hemicellulose associated with a variable amount of lignin. Many organisms participate in the aerobic degradation of cellulose in nature. A large number of rumen and soil microorganisms have been found to possess the ability to degrade native cellulose into simpler carbohydrates [1–5]. Much work has also been reported in developing methods for enzymatic hydrolysis of cellulose to glucose [6–11]. It has also been reported that enzymatic hydrolysis of natural cellulosic substances has been found inefficient without excessive grinding or substantial chemical pre-treatments [6, 12, 13]. Nutritive value of agricultural by-products was improved by the symbiotic action of different cellulolytic microorganism [14–16].

The present work was under-taken to improve the nutritive value of wheat straw by biological treatment to provide a cheap but nutritious feed available to the farmers.

MATERIALS AND METHODS

Wheat-straw was purchased from the local market and was ground to 20 mesh size for further treatments.

Wheat-straw was treated with different concentrations of sodium hydroxide (3.5–5.5 % w/s). Biodegradation of the untreated and pretreated straw was carried out by semi-solid fermentation technique.

Locally isolated cultures of *Chaetomium globosum* and *Bacillus polymyxa* were propagated in Reese medium [17] containing 2 % glucose and this broth was used as inoculum. 4 kg of the substrate containing 2 % urea was sterlized in 10 kg drum and inoculated keeping water to substrate ratio (v/w) 2:1. The substrate in the drum was mechnically agitated with a spindle fitted with blades (30 rpm). The batch was removed after 3 days and dried at 100±5°. Analytical methods were the same as reported elsewhere [18, 19].

Digestibility trials were carried out according to the rumen technique [20].

RESULTS AND DISCUSSIONS

Digestibility of Biodegraded Wheat Straw. Rumen digestibility of wheat straw biodegraded with *Chaetomium globosum, Bacillus polymyxa* and the combination of both microorganisms for different intervals of time (12–48 hr) is given in Table 1. Dry matter digestibility of wheat straw was 45.09 % with *Chaetomium globosum* and 42.27 % with *Bacillus polymyxa* after 48 hr incubation in the rumen of cow. However, it increased to 50.03 % when a combination of *Chaetomium globosum* and *Bacillus polymyxa* was employed. It is due to the fact that pure culture of a single organism has a fixed genetic make up, its physiological capacity and rate of degradation of cellulose is limited but these limitations were over-come by using combination of bacteria and mold in the fermentation process. Many workers [14–16] have reported an improvement in the degradation of cellulose by using mixed culture of cellulolytic microorganisms.

DIGESTIBILITY OF PRE-TREATED WHEAT STRAW AFTER FERMENTATION

a) *Dry Matter Digestibility of Wheat Straw: In vivo* digestibility of wheat straw after sodium hydroxide and

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Table 1. Rectuleo rumen digestibility of biodegraded wheat straw.

Treatment	Digestibility																			
	Dry matter				Nitrogen				Cellulose				Fibre				Minerals			
	Hours				Hours				Hours				Hours				Hours			
	12	24	36	48	12	24	36	48	12	24	36	48	12	24	36	48	12	24	36	48
Chaetomium globosum	29.71	36.68	38.89	45.09	21.11	23.63	25.55	26.71	3.25	4.98	6.98	8.88	5.12	6.66	7.23	8.97	31.27	33.55	36.81	39.77
B. polymyxa	31.26	37.08	39.00	42.27	22.89	24.66	29.60	30.77	5.68	9.31	7.21	10.26	6.89	7.77	8.99	9.25	34.71	35.55	37.88	39.98
B. polymyxa + *Chaetomium globosum*	29.14	36.64	44.50	50.03	25.96	25.79	39.72	39.39	3.12	8.48	12.68	12.76	7.14	12.99	16.40	23.52	43.63	42.56	45.56	47.55

biological treatment is recorded in Table 2. Dry matter digestibility of the straw after fermentation with a mixed culture of *Bacillus polymyxa* and *Chaetomium globosum* was 50.03 % in the cow's rumen after 48 hr (Table 1). Maximum dry matter digestibility was 68.83 % when a mixed culture of *Bacillus polymyxa* and *Chaetomium globosum* was propagated on treated wheat straw with 5.5 % sodium hydroxide. This improvement seems to be due to breaking up of the bond between lignin and structural polysaccharides by sodium hydroxide which rendered the substrate more susceptible to the action of rumen microorganisms. These findings are in agreement with the work of Han and Anderson [21] who reported an increase in *in vitro* digestibility of rye grass after chemical and microbial action. Improvement in the digestibility of various pretreated crop residues with cellulose degrading microbes was also reported by various workers [5, 10, 11, 22].

b) *Nitrogen Digestibility Wheat Straw.* Nitrogen digestibility of alkali treated straw after biodegradation with cellulolytic micro-organism is given in Table 3. A mixed culture of *Bacillus polymyxa* and *Chaetomium globosum* propagated on 4 % sodium hydroxide treated wheat straw increased nitrogen digestibility from 39.39 % to 89.32 % after 48 hr incubation in the rumen of cow. Our results are in agreement with the findings of Han [23] and Han and Anderson [21] who reported an increase in protein digestibility of straw after fermentation of alkali treated substrate.

c) *Cellulose Digestibility of Wheat Straw.* Improvement in cellulose digestibility of the treated straw is given in Table 4. A very significant improvement in cellulose digestibility was observed when alkali treated substrate was fermented with a mixed culture of Bacillus polymyxa and Chaetomium globosum. Maximum digestibility of cellulose present in the straw was 60.81. Negi and Kehar [24] found

Table 2. Rumen dry matter digestibility of treated wheat straw.

Treatment	Dry matter digestibility			
	Hours			
	12	24	36	48
3.5 % Sodium hydroxide biodegraded with *Chaetomium globosum* & *B. polymyxa.*	37.63	51.00	60.75	66.34
4.0 % Sodium hydroxide biodegraded with *Chaetomium globosum* & *B. polymyxa.*	43.24	48.30	59.35	59.82
4.5 % Sodium hydroxide biodegraded with *Chaetomium globosum* & *B. polymyxa.*	43.69	46.8	54.94	56.59
5.0 % Sodium hydroxide biodegraded with *Chaetomium globosum* & *B. polymyxa.*	42.90	52.1	63.51	62.48
5.5 % Sodium hydroxide biodegraded with *Chaetomium globosum* & *B. plymyxa.*	44.66	57.33	61.25	68.83

81 % increase in cellulose digestibility of rice straw by alkali treatment.

d) *Mineral Digestibility of Wheat Straw. In vivo* minerals digestibility of alkali treated straw followed by biological treatment is given in Table 5. It is evident from these results that the mineral digestibility was improved by treatment with different concentrations of sodium hydroxide and biological treatment. Maximum increase in mineral digestibility was 87.22 % when 5.5 % sodium hydroxide treated substrate was fermented with cellulolytic microorganisms. It can be concluded from these results that the digestibility of minerals improved due to formation of soluble salts of sodium.

e) *Fibre Digestibility of Wheat Straw.* Results presented in Table 6 show an improvement in fibre digestibility of the treated straw. Maximum fibre digestibility was 56.95 % when 5.5 % alkali treated straw was fermented with a mixed culture of *Bacillus polymyxa* and *Chaetomium globosum.* Han [23] reported 73 % increase in crude fibre digestibility of straw when sodium hydroxide treated straw was fermented. The increase in the digestibility appears to be due to the production of soluble carbohydrates which are readily digested by the cellulolytic microbes.

It is concluded from these findings that the dry matter, nitrogen, cellulose, minerals and fibre digestibility of alkali treated wheat straw was improved by the enzymatic hydrolysis. This improvement in the digestibility seems to be due to breaking up of the lignin cellulose bonds by sodium hydroxide treatment which made the cellulose present in the straw readily accessible to the microorganisms.

Table 3. Rumen digestibility of Nitrogen of Treated & biodegraded wheat straw.

Treatment	Nitrogen digestibility			
	Hours			
	12	24	36	48
3.5 % Sodium hydroxide biodegraded with *Chaetomium globosum & B. polymyxa.*	21.00	49.61	72.95	80.51
4.0 % Sodium hydroxide biodegrated with *Chaetomium globosum & B. polymyxa.*	73.96	75.65	87.34	89.32
4.5 % Sodium hydroxide biodegraded with *Chaetomium globosum & B. polymyxa.*	65.83	67.05	68.10	71.48
5.0 % Sodium hydroxide biodegraded with *Chaetomium globosum & B. polymyxa.*	78.04	81.67	81.67	82.00
5.5 % Sodium hydroxide biodegraded with *Chaetomium globosum & B. polymyxa.*	69.33	68.67	71.45	73.96

Table 4. Rumen digestibility of cellulose of treated and biodegrated wheat straw.

Treatment	Cellulose digestibility			
	Hours			
	12	24	36	48
3.5 % Sodium hydroxide biodegraded with *Chaetomium globosum & B. polymyxa.*	20.55	35.64	53.06	59.24
4.0 % Sodium hydroxide biodegraded with *Chaetomium globosum & B. polymyxa.*	11.27	15.23	30.23	37.91
4.5 % Sodium hydroxide biodegraded with *Chaetomium globosum & B. polymyxa.*	25.85	31.01	43.77	50.51
5.0 % Sodium hydroxide biodegraded with *Chaetomium globosum & B. polymyxa.*	15.07	24.09	46.26	50.33
5.5 % Sodium hydroxide biodegraded with *Chaetomium globosum & B. polymyxa.*	26.90	41.30	38.30	60.81

Table 5. Rumen digestibility of minerals of treated and biodegraded wheat straw.

Treatment of samples	Minerals digestibility			
	Hours			
	12	24	36	48
3.5 % NaOH, Biodegraded with *Chaetomium globosum* & *B. polymyxa.*	65.31	75.19	81.57	82.11
4 % NaOH + *B. polymyxa* + *Chaetomium globosum*	71.07	75.11	83.57	85.77
4.5 % NaOH + *B. Polymyxa* + *Chaetomium globosum*	72.01	71.49	81.04	79.81
5.0 % NaOH + *B. polymyxa* + *Chaetomium globosum*	74.32	82.01	83.34	82.92
5.5 % NaOH + *B. polymyxa* + *Chaetomium globosum*	76.04	79.34	83.58	87.22

Table 6. Rumen digestibility of fibre of treated and biodegraded wheat straw.

Treatment of samples	Fibre digestibility			
	Hours			
	12	24	36	48
3.5 % NaOH, Biodegraded with *Chaetomium globosum* & *B. polymyxa.*	4.63	22.94	39.62	51.75
4 % NaOH + *B. polymyxa* + *Chaetomium globosum*	21.79	29.47	37.53	40.13
4.5 % NaOH + *B. polymyxa* + *Chaetomium globosum*	26.89	33.25	43.90	46.77
5.0 % NaOH + *B. polymyxa* + *Chaetomium globosum*	14.75	25.30	47.51	47.80
5.5 % NaOH + *B. polymyxa* + *Chaetomium globosum*	31.52	39.50	49.08	56.95

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